AD-A116 654   AIR FORCE WRIGHT AERONAUTICAL LABS WRIGHT-PATTERSON AFB OH   F/G 11/4
INSTRUCTIONS FOR TI-59 COMBINED CARD/MODULE CALCULATIONS FOR IN--ETC(U)
MAR 82   S D GATES
UNCLASSIFIED   AFWAL-TR-81-4183   NL

1 OF 1
AD A
116654

END
DATE
FILMED
08-82
DTIC

(12)

AFWAL-TR-81-4183

INSTRUCTIONS FOR TI-59 COMBINED CARD/MODULE CALCULATIONS FOR IN-PLANE PROPERTIES OF SYMMETRIC HYBRID LAMINATES

Stella D. Gates

MECHANICS & SURFACE INTERACTIONS BRANCH
NONMETALLIC MATERIALS DIVISION

March 1982

Final Report for Period September 1981 - November 1981

Approved for public release; distribution unlimited.

MATERIALS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

NOTICE

This report has been reviewed by the Office of Public Affairs (ASD/PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

Stella D. Gates
STELLA D. GATES, Project Engineer
Mechanics and Surface Interactions Branch
Nonmetallic Materials Division

Tsai
STEPHEN W. TSAI, Chief
Mechanics and Surface Interactions Br
Nonmetallic Materials Division

FOR THE COMMANDER

Fred Cherry
F. D. CHERRY, Chief
Nonmetallic Materials Division

AIR FORCE/56780/24 June 1982 — 500

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFWAL-TR-81-4183	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) INSTRUCTIONS FOR TI-59 COMBINED CARD/MODULE CALCULATIONS FOR IN-PLANE PROPERTIES OF SYMMETRIC HYBRID LAMINATES		5. TYPE OF REPORT & PERIOD COVERED Final Technical Report September - November 1981
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Stella D. Gates		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Materials Laboratory (AFWAL/MLBM) Air Force Wright Aeronautical Laboratories Air Force Systems Command Wright-Patterson AFB, OH 45433		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 24190310
11. CONTROLLING OFFICE NAME AND ADDRESS Materials Laboratory (AFWAL/MLBM) Air Force Wright Aeronautical Laboratories Air Force Systems Command Wright-Patterson AFB, OH 45433		12. REPORT DATE March 1982
		13. NUMBER OF PAGES 40
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Magnetic Card Programs
Composite Materials Module
Composite Materials
Properties of Unidirectional & Laminated Composites
In-Plane Stiffness & Strength
Sandwich Core Laminates
Hybrid Laminates

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains the description and instructions for the combined use of composite materials module and magnetic cards for TI-59 programmable calculators. These programs contain the key calculations of the stiffness and strength of unidirectional, and laminated hybrid composites under in-plane loading. This can include sandwich core laminates. With the combination of the module and magnetic cards, instant calculations can be made for practical use. With the use of a printer, these can be immediately outputted and recorded permanently. The formulas used in the cards and equation numbers have

20. ABSTRACT (Cont'd)

been derived in a book entitled, Introduction to Composite Materials, co-authored by S. W. Tsai and H. T. Hahn, published by Technomic Publishing Company, Westport, Connecticut, July 1980.

FOREWORD

This report was prepared in the Mechanics and Surface Interactions Branch (AFWAL/MLBM), Nonmetallic Materials Division, Materials Laboratory, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, Ohio. The work was performed under the support of Project No. 2419, "Nonmetallic Structural Material", Task No. 241903, "Composite Materials and Mechanics Technology". The time period covered by this effort was from September to November 1981. Stella D. Gates (AFWAL/MLBM) was the laboratory project engineer.

The programs are written for Texas Instruments Calculators TI-59 to operate with or without a printer. However, the use of a printer is highly recommended. The specially designed "Composite Materials Module" must be installed in place of the standard "Master Module".

This report is meant to be used in conjunction with AFWAL-TR-81-4116, "Instructions for TI-59 Combined Card/Module Calculations for In-Plane and Flexural Properties of Symmetric Laminates", co-authored by S. W. Tsai and S. D. Gates; or with a revised expanded edition currently being published. In this report, the ideas previously presented are further developed to include the case of a symmetric hybrid laminate. Some of the previous information is repeated to facilitate the operation for a user.

Any references to equations and table numbers are the same as Introduction to Composite Materials, co-authored by S. W. Tsai and H. T. Hahn, published by Technomic Publishing Company, Westport, Connecticut, in July 1980.

The author wishes to acknowledge Stephen W. Tsai of the Materials Laboratory for his encouragement and helpful suggestions.

TABLE OF CONTENTS*

PAGE

INTRODUCTION

* Each Combo card description includes a flow chart, user instructions, register contents, and program listing.

** Sample problems are not given in these cards. They are similar to those in the on-printer cards, Combo 1P and 4P, respectively.

NOMENCLATURE

			LABEL NAME
A_{ij}	=	in-plane modulus; $i,j = 1,2,6$	A
a_{ij}	=	in-plane compliance; $i,j = 1,2,6$	AI
A^*_{ij}	=	normalized in-plane modulus; $i,j = 1,2,6$	A*
a^*_{ij}	=	normalized in-plane compliance; $i,j = 1,2,6$	A*I
c	=	half depth of core in equivalent number of plies	CR
E_i	=	engineering constants; $i = x,y,s$	E
E°_i	=	effective in-plane Young's and shear moduli; $i = 1,2,6$	E*
F_{ij}, F_i	=	strength parameters in stress space; $i,j = 1,2,6$	F
F^*_{xy}	=	normalized interaction term	FXY
G_{ij}, G_i	=	strength parameters in strain space; $i,j = 1,2,6$	G
h_o	=	unit ply thickness	H
N_i	=	stress resultants; $i = 1,2,6$ (Prompter 6.1, 6.2, 6.6)	N
$n^{(1)}$	=	total number of plies, material 1	N1
$n^{(2)}$	=	total number of plies, material 2; or material i	N2
Q_{ij}	=	on-axis modulus; $i,j = x,y,s$	Q
R_t, R'_t	=	tensile and compressive strength ratios	R
S	=	shear strength	-

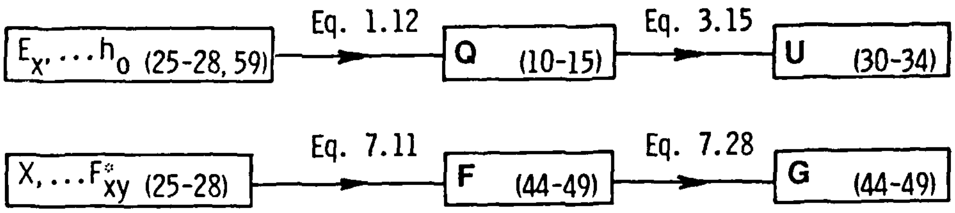
		NOMENCLATURE	LABEL NAME
S_{ij}	=	on-axis compliance; i,j = x,y,s	S
U_i	=	linear combinations of moduli; i = 1 to 5	-
X,X'	=	longitudinal tensile and compressive strengths	X
Y,Y'	=	transverse tensile and compressive strengths	-
ε_i^o	=	in-plane strain; i = 1,2,6	-
ν_x	=	longitudinal Poisson's ratio	-
ν_{21}^o	=	major in-plane Poisson's ratio	-
$\sigma_t^o, \sigma_t^{o\prime}$	=	allowable stresses, *in-plane loading*	Σ
Θ_t	=	ply orientation (TI 2-digit alphanumeric code = 60 as prompter)	↑

INTRODUCTION

Combos 4 and 4P are designed to allow the user to calculate the in-plane stiffness and strength of a symmetric, hybrid laminate. This laminate may be designed for two or more component materials and have a honeycomb core. The only difference between Combo 4 and 4P is the automatic print routine which occurs when Combo 4P is run while the TI-59 is attached to a printer.

A certain amount of caution must be used when working these programs because of the bookkeeping necessary when using two materials. Each material will have a different set of material properties and constants. Only one set can be kept in storage at any point in time. Therefore, it is necessary to keep track of the contents of certain data registers to maintain accuracy in calculation. More will be discussed in reference to this in the directions for each program.

AFWAL/MLBM CARD-MODULE COMBO FOR TI-59				
PLY DATA CARD			COMBO-1 P	
Ex,...	X,...	SI→ENGLISH	ENGLISH→SI	



Register locations are shown in parentheses. Equation and Table numbers are those in Introduction to Composite Materials, Tsai and Hahn.

COMBO #1P PLY DATA

STEP	PROCEDURE	PRESS	PRINTER LABEL	PRINTOUT	CALCULATOR PROMPTER
1a	Initialize program	A	E	-	4
b	Enter E_x	R/S	-	E_x	3
	E_y	R/S	-	E_y	2
	ν_x	R/S	-	ν_x	1
	E_s	R/S	-	E_s	0
	h_o	R/S	H	h_o	
			Q	Q_{11}, Q_{22}, Q_{12}, Q_{66}	
			S	S_{11}, S_{22}, S_{12}, S_{66}	
			U	U_1, U_2, U_3, U_4, U_5	
			A	A_{11}, A_{22}, A_{12}, A_{66}	
			AI	a_{11}, a_{22}, a_{12}, a_{66}	a_{66}
2a	Initialize program	B	X	-	5
b	Enter X	R/S	-	X	4
	X'	R/S	-	X'	3
	Y	R/S	-	Y	2
	Y'	R/S	-	Y'	1
	S	R/S	-	S	
			FXY		0
	Enter F^*_{xy}	R/S		F^*_{xy}	
		F		F_{xx}, F_{yy}, F_{xy}, F_{ss}, F_x, F_y	
		G		G_{xx}, G_{yy}, G_{xy}, G_{ss}, G_x, G_y	G_y

COMBO #IP CONTINUED

STEP	PROCEDURE	PRESS	PRINTER LABEL	PRINTOUT	CALCULATOR PROMPTER
3	Convert SI → English	C	U' H'	$U_1', U_2', U_3', U_4', U_5'$ h_o'	h_o'
4	Convert English → SI	D	U' H'	$U_1', U_2', U_3', U_4', U_5'$ h_o'	h_o'

COMBO 1P PLY DATA (W/PRT) 28 JUL 81

```
000  76 LBL
001  11  A
002  47 CMS
003  57 ENG
004  58 FIX
005  03  03
006  01  1
007  [illegible]
008  00  0
009  00  0
010  42 STO
011  02  02
012  36 PGM
013  11  11
014  71 SBR
015  90 LST
016  04  4
017  95  =
018  91 R/S   Ex
019  42 STO
020  25  25
021  99 PRT
022  01  1
023  95  =
024  91 R/S
025  42 STO
026  26  26   Ey
027  99 PRT
028  02  2
029  95  =
030  91 R/S
031  42 STO   Vx
032  28  28
033  99 PRT
034  01  1
035  95  =
036  91 R/S
037  42 STO   Es
038  27  27
039  99 PRT
040  98 ADV
041  00  0
042  95  =
043  91 R/S
044  42 STO   ho
045  59  59
046  02  2
047  03  3
048  00  0
049  00  0
050  42 STO
051  02  02
052  36 PGM
053  11  11
054  71 SBR
055  90 LST
056  43 RCL
057  59  59
058  99 PRT
059  98 ADV

060  36 PGM
061  01  01
062  71 SBR
063  57 ENG   Qij
064  03  3
065  04  4
066  00  0
067  00  0
068  42 STO
069  02  02
070  36 PGM
071  11  11
072  71 SBR
073  90 LST
074  43 RCL
075  10  10
076  99 PRT
077  43 RCL
078  11  11
079  99 PRT
080  43 RCL
081  12  12
082  99 PRT
083  43 RCL
084  13  13
085  99 PRT
086  98 ADV
087  36 PGM
088  11  11
089  71 SBR
090  35 1/X   Sij
091  03  3
092  06  6
093  00  0
094  00  0
095  42 STO
096  02  02
097  36 PGM
098  11  11
099  71 SBR
100  90 LST
101  43 RCL
102  16  16
103  99 PRT
104  43 RCL
105  17  17
106  99 PRT
107  43 RCL
108  18  18
109  99 PRT
110  43 RCL
111  19  19
112  99 PRT
113  98 ADV
114  36 PGM
115  01  01
116  71 SBR   Ui
117  52  EE
118  04  4
119  01  1

120  00  0
121  00  0
122  42 STO
123  02  02
124  36 PGM
125  11  11
126  71 SBR
127  90 LST
128  43 RCL
129  30  30
130  99 PRT
131  43 RCL
132  31  31
133  99 PRT
134  43 RCL
135  32  32
136  99 PRT
137  43 RCL
138  33  33
139  99 PRT
140  43 RCL
141  34  34
142  99 PRT
143  98 ADV
144  01  1
145  03  3
146  00  0
147  00  0
148  42 STO
149  02  02
150  36 PGM
151  11  11
152  71 SBR
153  90 LST
154  43 RCL
155  10  10   Aij
156  65  ×
157  43 RCL
158  59  59
159  95  =
160  99 PRT
161  43 RCL
162  11  11
163  65  ×
164  43 RCL
165  59  59
166  95  =
167  99 PRT
168  43 RCL
169  12  12
170  65  ×
171  43 RCL
172  59  59
173  95  =
174  99 PRT
175  43 RCL
176  13  13
177  65  ×
178  43 RCL
179  59  59

180  95  =
181  99 PRT
182  98 ADV
183  01  1
184  03  3
185  02  2
186  04  4
187  42 STO
188  02  02
189  36 PGM
190  11  11
191  71 SBR
192  90 LST
193  43 RCL
194  16  16   Aij
195  55  ÷
196  43 RCL
197  59  59
198  95  =
199  99 PRT
200  43 RCL
201  17  17
202  55  ÷
203  43 RCL
204  59  59
205  95  =
206  99 PRT
207  43 RCL
208  18  18
209  55  ÷
210  43 RCL
211  59  59
212  95  =
213  99 PRT
214  43 RCL
215  19  19
216  55  ÷
217  43 RCL
218  59  59
219  95  =
220  99 PRT
221  98 ADV
222  91 R/S
223  76 LBL
224  12  B
225  57 ENG
226  58 FIX
227  03  03
228  04  4
229  04  4
230  00  0
231  00  0
232  42 STO
233  02  02
234  36 PGM
235  11  11
236  71 SBR
237  90 LST
238  05  5
239  95  =
```

COMBO 1P PLY DATA (W/PRT) 28 JUL 81

```
[illegible]                      X
                                 X'
                                 y
                                 y'
                                 S
     42  STO
     35  =
     91  R/S
     42  STO                     Fxy*
     99  PRT
     98  ADV
     36  PGM
     08  08
     71  SBR                     Fij
     98  ADV
     02  2
     01  1
     00  0
     00  0
     42  STO
     02  02
     36  PGM
     11  11
```

```
[illegible]                      Gij
     99  PRT
     42  STO
     45  45
     43  RCL
     18  18
     99  PRT
     42  STO
     46  46
     43  RCL
     19  19
     99  PRT
     42  STO
354  47  47
355  43  RCL
356  20  20
357  99  PRT
358  42  STO
359  48  48
```

```
[illegible]
------------------------
                         SI→ Engl.
[illegible]
------------------------
                         Engl. →SI
     49  PRD
     30  30
     49  PRD
     31  31
     49  PRD
     32  32
     49  PRD
     33  33
     49  PRD
     34  34
     95  =
     03  3
     09  9
     93  .
     04  4
416  55  ÷
417  49  PRD
418  59  59
------------------------
419  76  LBL
```

```
[illegible]                      U'_i
                                 h'_0
     99  PRT
     98  ADV
     91  R/S
462  00  0
463  00  0
464  00  0
465  00  0
466  00  0
467  00  0
468  00  0
469  00  0
470  00  0
471  00  0
472  00  0
473  00  0
474  00  0
475  00  0
476  00  0
477  00  0
478  00  0
479  00  0
```

```
                T300/5208                                B(4)/5505

       SI                 ENGLISH               SI                 ENGLISH
                                                                      E
        E                   E                    E               29.587 06
      181.000 09         26.251 06          204.000 09            2.683 06
 I     10.300 09          1.494 06           18.500 09          230.000-03
 N    280.000-03        280.000-03          230.000-03          810.732 03
 P      7.170 09          1.040 06            5.590 09
 U                                                                    H
 T      H                   H                   H                4.925-03
      125.000-06          4.925-03          125.000-06

        Q                   Q                   Q                     Q
      181.811 09         26.369 06          204.983 09           29.729 06
       10.346 09          1.501 06           18.589 09            2.696 06
        2.897 09        420.149 03            4.276 09          620.089 03
        7.170 09          1.040 06            5.590 09          810.732 03

        S                   S                   S                     S
        5.525-12         38.094-09            4.902-12           33.799-09
       97.087-12        669.417-09           54.054-12          372.703-09
       -1.547-12        -10.666-09           -1.127-12           -7.774-09
      139.470-12        961.646-09          178.891-12            1.233-06

        U                   U                   U                     U
       76.368 09         11.076 06           87.704 09           12.720 06
       85.732 09         12.434 06           93.197 09           13.517 06
       19.710 09          2.859 06           24.083 09            3.493 06
       22.607 09          3.279 06           28.358 09            4.113 06
       26.880 09          3.899 06           29.673 09            4.304 06

        A                   A                   A                     A
       22.725 06        129.765 03           25.622 06          146.417 03
        1.293 06          7.390 03            2.324 06           13.278 03
      362.116 03          2.069 03          534.429 03            3.054 03
      896.160 03          5.121 03          698.750 03            3.992 03

        AI                  AI                  AI                    AI
       44.199-09          7.735-06           39.216-09            6.863-06
      773.899-09        135.422-06          432.412-09           75.676-06
      -12.376-09         -2.166-06           -9.020-09           -1.578-06
        1.116-06        195.358-06            1.431-06          250.447-06

        1.500 09        217.549 03            1.260 09          182.741 03
 I      1.500 09        217.549 03            2.500 09          362.582 03
 N     40.000 06          5.801 03           61.000 06            8.847 03
 P    246.000 06         35.678 03          202.000 06           29.297 03
 U     68.000 06          9.862 03           67.000 06            9.717 03
 T
        F                   F                   F                     F
     -500.000-03       -500.000-03         -500.000-03         -500.000-03

        F                   F                   F                     F
      444.444-21         21.129-12          317.460-21           15.092-12
      101.626-18          4.831-09           81.156-18            3.858-09
       -3.360-18       -159.753-12           -2.538-18         -120.654-12
      216.263-18         10.281-09          222.767-18           10.591-09
        0.000 00          0.000 00          393.651-12            2.714-06
       20.935-09        144.347-06           11.443-09           78.899-06

        G                   G                   G                     G
       12.004 03         12.004 03           10.374 03           10.374 03
       10.681 03         10.681 03           27.646 03           27.646 03
       -3.069 03         -3.069 03           -2.989 03           -2.989 03
       11.118 03         11.118 03            6.961 03            6.961 03
       60.647 00         60.647 00          129.616 00          129.616 00
      216.596 00        216.596 00          214.398 00          214.398 00


        U*                  U*                  U*                    U*
       11.076 06         76.368 09           12.720 06           87.704 09
       12.434 06         85.732 09           13.517 06           93.197 09
        2.859 06         19.710 09            3.493 06           24.083 09
        3.279 06         22.607 09            4.113 06           28.358 09
        3.899 06         26.880 09            4.304 06           29.673 09

        H*                  H*                  H*                    H*
        4.925-03        125.000-06            4.925-03          125.000-06
```

```
                         AS/3501                              SCOTCHPLY 1002

               SI                 ENGLISH                 SI                 ENGLISH
               E                    E                     E                    E
         ( 138.000 09          20.015 06             38.600 09            5.598 06
         (   8.960 09           1.299 06              8.270 09            1.199 06
         ( 300.000-03         300.000-03            260.000-03          260.000-03
   INPUT (   7.100 09           1.030 06              4.140 09          600.415 03
         (
         (     H                    H                     H                    H
         ( 125.000-06           4.925-03            125.000-06            4.925-03

               Q                    Q                     Q                    Q
           138.811 09          20.132 06             39.167 09            5.681 06
             9.011 09           1.307 06              8.392 09            1.217 06
             2.704 09         392.139 03              2.182 09          316.412 03
             7.100 09           1.030 06              4.140 09          600.415 03

               S                    S                     S                    S
             7.246-12          49.964-09             25.907-12          178.627-09
           111.607-12         769.531-09            120.919-12          833.736-09
            -2.174-12         -14.989-09             -6.736-12          -46.443-09
           140.845-12         971.137-09            241.546-12            1.665-06

               U                    U                     U                    U
            59.660 09           8.651 06             20.450 09            2.966 06
            64.900 09           9.412 06             15.388 09            2.232 06
            14.252 09           2.067 06              3.329 09          482.872 03
            16.956 09           2.459 06              5.511 09          799.304 03
            21.352 09           3.097 06              7.469 09            1.083 06

               A                    A                     A                    A
            17.351 06          99.151 03              4.896 06           27.979 03
             1.126 06           6.438 03              1.049 06            5.994 03
           338.[illegible] 03           1.931 03            272.725 03            1.558 03
           887.500 03           5.071 03            517.500 03            2.957 03

               A*                   A*                    A*                   A*
            57.971-09          10.145-06            207.254-09           36.269-06
           892.857-09         156.250-06            967.352-09          169.287-06
           -17.391-09          -3.043-06            -53.886-09           -9.430-06
             1.127-06         197.133-06              1.932-06          338.164-06

         (   1.447 09         209.862 03              1.062 09          154.025 03
         (   1.447 09         209.862 03            610.000 06           88.470 03
         ( [illegible]               7.498 03             31.000 06            4.496 03
   INPUT ( [illegible]              29.877 03            118.000 06           17.114 03
         ( [illegible]              13.488 03             72.000 06           10.442 03
         (
         (     F                    F                     F                    F
         (-500.000-03        -500.000-03           -500.000-03         -500.000-03

               F                    F                     F                    F
           477.598-21          22.706-12              1.544-18           73.386-12
            93.895-18           4.464-09            273.373-18           12.996-09
            -3.348-18        -159.181-12            -10.271-18         -488.303-12
           115.620-18           5.497-09            192.901-18            9.171-09
             0.000 00           0.000 00           -697.725-12           -4.811-06
            14.488-09          99.895-06             23.783-09          163.987-06

               G                    G                     G                    G
             7.[illegible]76 03           7.[illegible]76 03              1.914 03            1.914 03
             7.467 03           7.467 03             18.[illegible]82 03           18.[illegible]82 03
            -1.746 03          -1.746 03              1.712 03            1.712 03
             5.828 03           5.828 03              3.106 03            3.106 03
            24.173 00          24.173 00             24.563 00           24.563 00
           1[illegible].575 00          1[illegible].575 00             14[illegible].658 00          14[illegible].658 00


               U*                   U*                    U*                   U*
             8.651 06          59.660 09              2.966 06           20.450 09
             9.412 06          64.900 09              2.232 06           15.388 09
             2.067 06          14.252 09            482.872 03            3.329 09
             2.459 06          16.956 09            799.304 03            5.511 09
             3.097 06          21.352 09              1.083 06            7.469 09

               H*                   H*                    H*                   H*
             4.925-03         125.000-06              4.925-03          125.000-06
```

	KEVLAR 49/EPOXY		ALUMINUM	
	SI	ENGLISH	SI	ENGLISH
INPUT	E	E	E	E
	76.000 09	11.022 06	69.000 09	10.007 06
	5.500 09	797.679 03	69.000 09	10.007 06
	340.000-03	340.000-03	300.000-03	300.000-03
	2.300 09	333.575 03	26.538 09	3.849 06
	H	H	H	H
	125.000-06	4.925-03	1.000 00	1.000 00
	Q	Q	Q	Q
	76.641 09	11.115 06	75.824 09	10.997 06
	5.546 09	804.409 03	75.824 09	10.997 06
	1.886 09	273.499 03	22.747 09	3.299 06
	2.300 09	333.575 03	26.538 09	3.849 06
	S	S	S	S
	13.158-12	90.724-09	14.493-12	99.928-09
	181.818-12	1.254-06	14.493-12	99.928-09
	-4.474-12	-30.846-09	-4.348-12	-29.978-09
	434.783-12	2.998-06	37.681-12	259.812-09
	U	U	U	U
	32.442 09	4.705 06	75.824 09	10.997 06
	35.547 09	5.156 06	0.000 00	0.000 00
	8.652 09	1.255 06	40.000-03 ≈0	88.455-03 ≈0
	10.538 09	1.528 06	22.747 09	3.299 06
	10.952 09	1.588 06	26.538 09	3.849 06
	A	A	A	A
	9.580 06	54.744 03	75.824 09	10.997 06
	693.300 03	3.962 03	75.824 09	10.997 06
	235.722 03	1.347 03	22.747 09	3.299 06
	287.500 03	1.643 03	26.538 09	3.849 06
	AI	AI	AI	AI
	105.263-09	18.421-06	14.493-12	99.928-09
	1.455-06	254.545-06	14.493-12	99.928-09
	-35.789-09	-6.263-06	-4.348-12	-29.978-09
	3.478-06	608.696-06	37.681-12	259.812-09
INPUT	[illegible]	[illegible]	[illegible]	[illegible]
	1.400 09	203.046 03	400.000 06	58.[illegible] 03
	235.000 06	34.083 03	400.000 06	58.[illegible] 03
	12.000 06	1.740 03	400.000 06	58.[illegible] 03
	53.000 06	7.687 03	400.000 06	58.[illegible] 03
	34.000 06	4.931 03	230.000 06	[illegible].159 03
	F[illegible]	F[illegible]	F[illegible]	F[illegible]
	-500.000-03	-500.000-03	-500.000-03	-500.000-03
	F	F	F	F
	2.040-18	144.502-12	6.250-18	297.131-12
	1.572-15	74.750-09	6.250-18	297.131-12
	-34.566-18	-1.643-09	-3.125-18	-148.566-12
	865.052-18	41.135-09	18.904-18	898.396-12
	-1.541-09	-24.415-06	0.000 00	0.000 00
	64.465-09	444.489-06	0.000 00	0.000 00
	G	G	G	G
	13.454 03	13.454 03	28.387 03	28.387 03
	47.657 03	47.657 03	28.387 03	28.387 03
	2.069 03	2.069 03	1.976 03	1.976 03
	4.576 03	4.576 03	13.314 03	13.314 03
	-149.922 00	-149.622 00	0.000 00	0.000 00
	350.873 00	350.873 00	0.000 00	0.000 00
	U*	U*	U*	U*
	4.705 06	32.442 09	10.997 06	75.824 09
	5.156 06	35.547 09	0.000 00	0.000 00
	1.255 06	8.652 09	5.801-06 ≈0	609.397 00 ≈0
	1.528 06	10.538 09	3.299 06	22.747 09
	1.588 06	10.952 09	3.849 06	26.538 09
	H*	H*	H*	H*
	4.925-03	125.000-06	39.400 00	25.381-03

NOTES

<table>
<tr><th colspan="5">AFWAL/MLBM CARD-MODULE COMBO FOR TI-59</th></tr>
<tr><td colspan="4">SELECTED PLY DATA CARD D</td><td>COMBO -1</td></tr>
<tr><td>AL</td><td></td><td></td><td></td><td>SI←ENGLISH</td></tr>
<tr><td>T-300</td><td>B</td><td>AS</td><td>SCOTCH</td><td>KEVLAR</td></tr>
</table>

$$\begin{tikzcd}
\boxed{E_x, \ldots h_0 \ (25\text{-}28, 59)} \arrow[r, "\text{Eq. } 1.12"] & \boxed{Q \ (10\text{-}15)} \arrow[r, "\text{Eq. } 3.15"] & \boxed{U \ (30\text{-}34)} \\
\boxed{X, \ldots F^*_{xy} \ (25\text{-}28)} \arrow[r, "\text{Eq. } 7.11"] & \boxed{F \ (44\text{-}49)} \arrow[r, "\text{Eq. } 7.28"] & \boxed{G \ (44\text{-}49)}
\end{tikzcd}$$

Register locations are shown in parentheses. Equation and Table numbers are those in Introduction to Composite Materials, Tsai and Hahn.

COMBO #1 SELECTED PLY DATA

STEP	PROCEDURE	PRESS	DISPLAY
1	Enter material properties		
a	T300/5208	A	216.59641
b	B(4)/5505	B	214.39805
c	AS/3501	C	130.57541
d	Scotchply 1002	D	198.05771
e	Kevlar 49/Epoxy	E	350.87335
f	Aluminum	A'	0
2	Convert SI → English	E'	39.4

A pre-recorded data card should be made for each material in order to facilitate using Combos 4 and 4P. This entails recording the data generated by Combo 1 into Bank #3 (30-59) of a magnetic card. To do this, enter the material properties of the material of interest by pushing the appropriate button. Push $\boxed{3}$ $\boxed{\text{2nd}}$ $\boxed{\text{Write}}$ and feed a blank magnetic card through the card reader. This has recorded the necessary data. Label the card and save it. Two materials may be put on each card, one on each side. For more information, consult the manuel that came with your TI-59.

COMBO 1 PLY DATA (SELECTED) 28 JUL 81

```
000  76  LBL
001  11   A
002  47  CMS
003  57  ENG
004  01   1   T300-
005  08   8   5208
006  01   1
007  52  EE
008  09   9
009  42  STO
010  25   25  Ex
011  01   1
012  00   0
013  03   3
014  52  EE
015  08   8
016  42  STO
017  26   26  Ey
018  07   7
019  01   1
020  07   7
021  52  EE
022  07   7
023  42  STO
024  27   27  Es
025  93   .
026  02   2
027  08   8
028  42  STO
029  28   28  Vx
030  01   1
031  02   2
032  05   5
033  52  EE
034  06   6
035  94  +/-
036  42  STO  ho
037  59   59
038  71  SBR
039  35  1/X
040  36  PGM
041  08   08
042  10  E'   x,...
043  71  SBR
044  45  YX
---------------
045  76  LBL
046  35  1/X
047  36  PGM
048  01   01
049  71  SBR
050  57  ENG  Qij
051  36  PGM
052  01   01
053  71  SBR
054  52  EE   Ui
055  92  RTN
---------------
056  76  LBL
057  45  YX
058  36  PGM
059  08   08

060  71  SBR
061  98  ADV  Fij
062  36  PGM
063  08   08
064  71  SBR
065  80  GRD  Gij
066  43  RCL
067  16   16
068  42  STO
069  44   44
070  43  RCL
071  17   17
072  42  STO
073  45   45
074  43  RCL
075  18   18
076  42  STO
077  46   46
078  43  RCL
079  19   19
080  42  STO
081  47   47
082  43  RCL
083  20   20
084  42  STO
085  48   48
086  43  RCL
087  21   21
088  42  STO
089  49   49
090  91  R/S
---------------
091  76  LBL
092  13   C
093  47  CMS
094  57  ENG
095  01   1   AS-
096  03   3   3501
097  08   8
098  52  EE
099  09   9
100  42  STO
101  25   25
102  08   8
103  09   9
104  06   6
105  52  EE
106  07   7
107  42  STO
108  26   26
109  07   7
110  01   1
111  52  EE
112  08   8
113  42  STO
114  27   27
115  93   .
116  03   3
117  42  STO
118  28   28
119  01   1

120  02   2
121  05   5
122  52  EE
123  06   6
124  94  +/-
125  42  STO
126  59   59
127  71  SBR
128  35  1/X
129  01   1
130  04   4
131  04   4
132  07   7
133  52  EE
134  06   6
135  42  STO
136  23   23
137  42  STO
138  24   24
139  05   5
140  01   1
141  07   7
142  52  EE
143  05   5
144  42  STO
145  25   25
146  02   2
147  00   0
148  06   6
149  52  EE
150  06   6
151  42  STO
152  26   26
153  09   9
154  03   3
155  52  EE
156  06   6
157  42  STO
158  27   27
159  93   .
160  05   5
161  94  +/-
162  42  STO
163  28   28
164  71  SBR
165  45  YX
---------------
166  76  LBL
167  14   D
168  47  CMS
169  57  ENG
170  03   3   Scotca-
171  08   8   Ply
172  06   6   1002
173  52  EE
174  08   8
175  42  STO
176  25   25
177  08   8
178  02   2
179  07   7

180  52  EE
181  07   7
182  42  STO
183  26   26
184  04   4
185  01   1
186  04   4
187  52  EE
188  07   7
189  42  STO
190  27   27
191  93   .
192  02   2
193  06   6
194  42  STO
195  28   28
196  01   1
197  02   2
198  05   5
199  52  EE
200  06   6
201  94  +/-
202  42  STO
203  59   59
204  71  SBR
205  35  1/X
206  01   1
207  00   0
208  06   6
209  02   2
210  52  EE
211  06   6
212  42  STO
213  23   23
214  06   6
215  01   1
216  52  EE
217  07   7
218  42  STO
219  24   24
220  03   3
221  01   1
222  52  EE
223  06   6
224  42  STO
225  25   25
226  01   1
227  01   1
228  08   8
229  52  EE
230  06   6
231  42  STO
232  26   26
233  07   7
234  02   2
235  52  EE
236  06   6
237  42  STO
238  27   27
239  93   .
```

COMBO 1 PLY DATA (SELECTED) 28 JUL 81

```
240  05  5
241  94  +/-
242  42  STO
243  28  28
244  71  SBR
245  45  [illegible]
---------------------
246  76  LBL
247  16  A'
248  47  CMS
249  57  ENG
[illegible]
[illegible]
252  52  EE
253  03  [illegible]
254  42  STO
[illegible]
256  42  STO
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
263  42  STO
[illegible]
[illegible]
[illegible]
267  42  STO
[illegible]
269  01  1
270  42  STO
271  59  59
272  71  SBR
273  35  1/X
274  04  4
275  52  EE
276  08  8
277  42  STO
[illegible]
279  42  STO
[illegible]
281  42  STO
282  25  25
283  42  STO
284  26  26
[illegible]
[illegible]
287  52  EE
[illegible]
289  42  STO
[illegible]
[illegible]
[illegible]
[illegible]
294  42  STO
[illegible]
296  71  SBR
297  45  [illegible]
---------------------
298  76  LBL
299  10  E'
```

Aℓ

```
300  06  6
301  08  8
302  09  9
303  05  5
304  35  1/X
305  49  PRD
306  30  30
307  49  PRD
308  31  31
309  49  PRD
310  32  32
311  49  PRD
312  33  33
313  49  PRD
314  34  34
315  95  =
316  03  3
317  09  9
318  93  .
319  04  4
320  49  PRD
[illegible]
[illegible]
---------------------
323  76  LBL
324  15  E
325  47  CMS
326  57  ENG
327  03  3
328  00  0
329  04  4
330  52  EE
331  03  [illegible]
332  42  STO
333  25  25
334  01  1
335  08  8
336  93  .
337  05  5
338  52  EE
339  04  4
340  42  STO
341  26  26
342  93  .
343  02  2
344  03  3
345  42  STO
346  28  28
347  05  5
348  93  .
349  05  5
350  09  9
351  52  EE
352  09  [illegible]
353  42  STO
[illegible]
355  01  1
356  02  2
357  05  5
358  52  EE
359  06  6
```

SI → Engl.

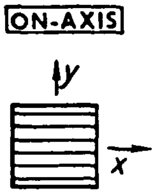
B(4)/ 5505

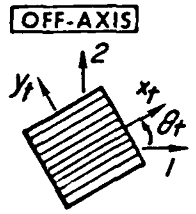
```
360  94  +/-
361  42  STO
362  59  59
363  71  SBR
364  35  1/X
365  01  1
366  02  2
367  06  6
368  52  EE
369  07  7
370  42  STO
371  23  23
372  03  3
373  05  5
374  52  EE
375  08  8
376  42  STO
377  24  24
378  06  6
379  01  1
380  52  EE
381  06  6
382  42  STO
383  25  25
384  02  2
385  00  0
386  02  2
387  52  EE
388  06  6
389  42  STO
390  26  26
391  06  6
392  07  7
393  52  EE
394  06  6
395  42  STO
396  27  27
397  93  .
398  05  5
399  94  +/-
400  42  STO
401  28  28
402  71  SBR
403  45  [illegible]
---------------------
404  76  LBL
405  15  E
406  47  CMS
407  57  ENG
408  07  7
409  06  6
410  52  EE
411  03  [illegible]
412  42  STO
[illegible]
[illegible]
415  05  5
416  52  EE
417  08  8
418  42  STO
419  26  26
```

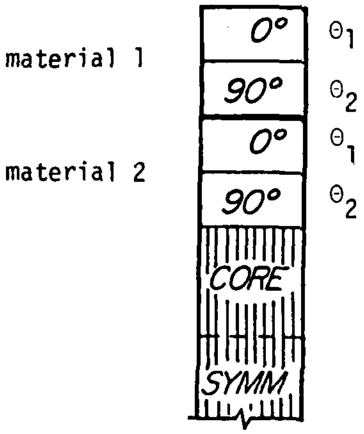
Kevlar 49/ Epoxy

```
420  02  2
421  03  3
422  52  EE
423  08  8
424  42  STO
425  27  27
426  93  .
427  03  3
428  04  4
429  42  STO
430  28  28
431  01  1
432  02  2
433  05  5
434  52  EE
435  06  6
436  94  +/-
437  42  STO
438  59  59
439  71  SBR
440  35  1/X
441  01  1
442  04  4
443  52  EE
444  08  8
445  42  STO
446  23  23
447  03  3
448  03  3
449  05  5
450  52  EE
[illegible]
452  42  STO
[illegible]
[illegible]
[illegible]
456  52  EE
[illegible]
458  42  STO
459  25  25
[illegible]
461  03  [illegible]
462  52  EE
463  06  6
464  42  STO
465  26  26
[illegible]
467  04  4
468  52  EE
469  06  [illegible]
470  42  STO
[illegible]
[illegible]
[illegible]
474  94  +/-
475  42  STO
476  28  28
477  71  SBR
478  45  [illegible]
479  00  0
```

NOTES



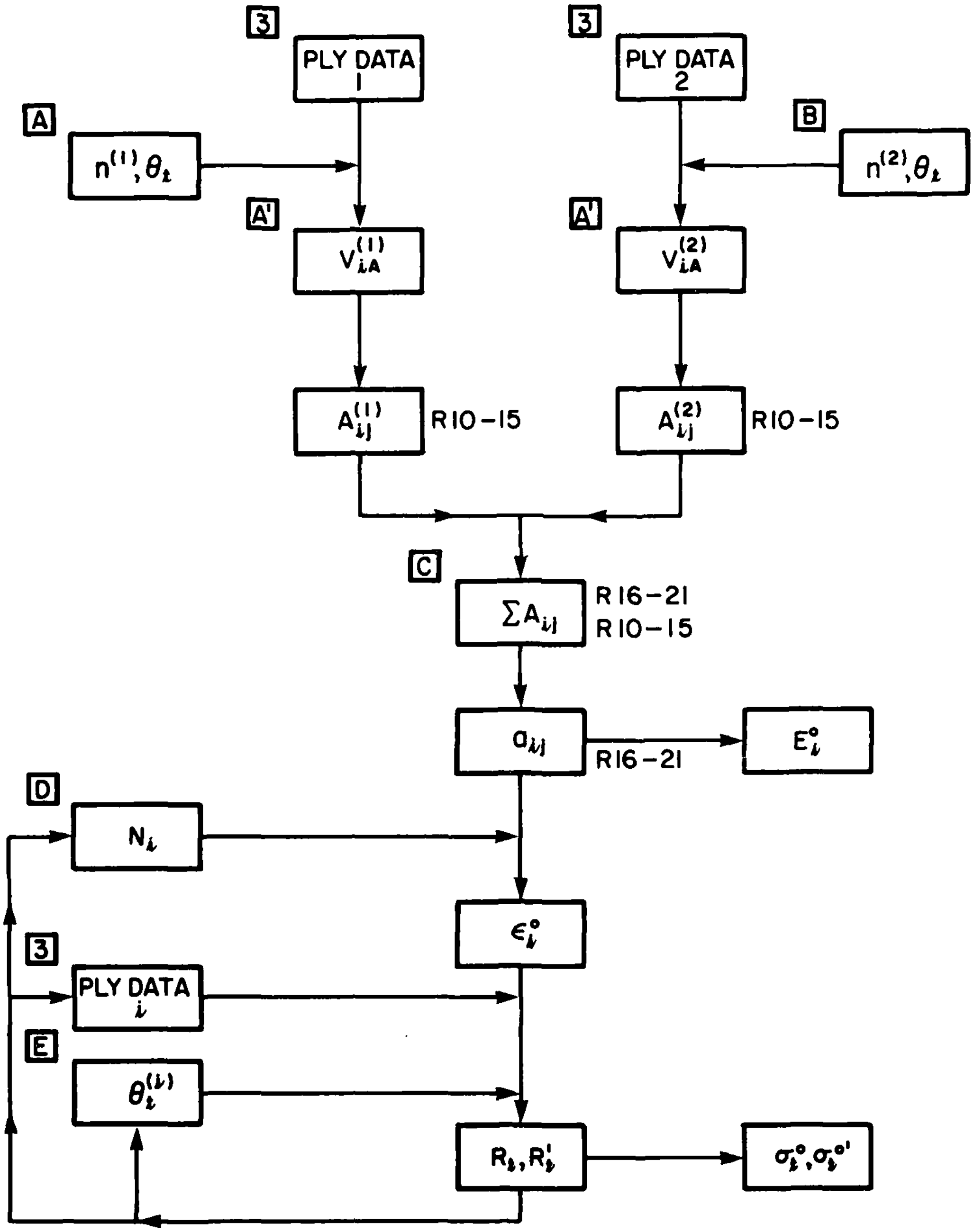




$[0^{(1)}/90^{(1)}/0^{(2)}/90^{(2)}/C_2]_s$

EXAMPLE OF LAMINATE STACKING SEQUENCE

COMBO #4P (PRT)
HYBRID: IN-PLANE STIFFNESS AND STRENGTH



COMBO #4P HYBRID: IN-PLANE STIFFNESS AND STRENGTH

A' core	**B'**	**C'**	**D'**	**E'**
A material 1 $n^{(1)}, \Theta_t^{(1)}$	**B** material i $n^{(i)}, \Theta_t^{(i)}$	**C** $A_{ij}, a_{ij}, E_i^\circ, A_{ij}^*$	**D** $N_i \rightarrow \varepsilon_i^\circ$	**E** $\Theta_t \rightarrow R_t, \sigma^\circ$

00 USED	**15** $A_{26}^{(i)}$	**30** $U_1^{(i)}$	**45** $G_{yy}^{(i)}$
01 USED	**16** $\Sigma A_{11}^{(i)}, a_{11}, G_{xx}^{(i)}$	**31** $U_2^{(i)}$	**46** $G_{xy}^{(i)}$
02 USED	**17** $\Sigma A_{22}^{(i)}, a_{22}, G_{yy}^{(i)}$	**32** $U_3^{(i)}$	**47** $G_{ss}^{(i)}$
03 USED	**18** $\Sigma A_{12}^{(i)}, a_{12}, G_{xy}^{(i)}$	**33** $U_4^{(i)}$	**48** $G_x^{(i)}$
04 USED	**19** $\Sigma A_{66}^{(i)}, a_{66}, G_{ss}^{(i)}$	**34** $U_5^{(i)}$	**49** $G_y^{(i)}$
05 $n^{(i)}$, c	**20** $\Sigma A_{16}^{(i)}, a_{16}, G_x^{(i)}$	**35** Θ	**50**
06 R_t	**21** $\Sigma A_{26}^{(i)}, a_{26}, G_y^{(i)}$	**36** $V_0^{(i)}$	**51**
07 R_t'	**22** $\lvert A \rvert$	**37** $V_1^{(i)}$	**52**
08 1/h	**23** ε_i°	**38** $V_3^{(i)}$	**53** p
09 h	**24** ε_2°	**39** $V_2^{(i)}$, USED	**54** q
10 $A_{11}^{(i)}$	**25** ε_6°	**40** $V_4^{(i)}$	**55** r
11 $A_{22}^{(i)}$	**26** N_1, 0	**41** Θ	**56** USED
12 $A_{12}^{(i)}$	**27** N_2, 0	**42** USED	**57** USED
13 $A_{66}^{(i)}$	**28** N_6, 0	**43** USED	**58** USED
14 $A_{16}^{(i)}$	**29** USED	**44** $G_{xx}^{(i)}$	**59** h_0

COMBO #4P HYBRID: IN-PLANE STIFFNESS AND STRENGTH

STEP	PROCEDURE	PRESS	PRINTER LABEL	PRINTOUT	CALCULATOR PROMPTER
0	Enter ply data #1	3	-	-	3
1a	Enter $n^{(1)}$	A	N1	$n^{(1)}$	n/2
b	Θ_1	R/S	-	Θ_1	n/2 - 1
c	Θ_2	R/S	-	Θ_2	n/2 - 2
⋮	⋮	⋮		⋮	⋮
	$\Theta_{n/2 - 1}$	R/S	-	$\Theta_{n/2 - 1}$	1
*	$\Theta_{n/2}$	R/S	-	$\Theta_{n/2}$	0
			SYM		
2	Enter ply data #2	3	-	-	3
3a	Enter $n^{(2)}$	B	N2	$n^{(2)}$	n/2
b	Θ_1	R/S	-	Θ_1	n/2 - 1
c	Θ_2	R/S	-	Θ_2	n/2 - 2
⋮	⋮	⋮		⋮	⋮
	$\Theta_{n/2 - 1}$	R/S	-	$\Theta_{n/2 - 1}$	1
	$\Theta_{n/2}$	R/S	-	$\Theta_{n/2}$	0
			SYM		
4	Print A_{ij}, a_{ij}	C	A	A_{11}, A_{22}, A_{12}, A_{66}, A_{16}, A_{26}	
	E°_i, A^*_{ij}			a_{11}, a_{22}, a_{12}, a_{66}, a_{16}, a_{26}	
			E*	E°_1, E°_2, ν°_{21}, E°_6	
			A*	A^*_{11}, A^*_{22}, A^*_{12}, A^*_{66}, A^*_{16}, A^*_{26}	6.1

COMBO #4P CONTINUED

STEP	PROCEDURE	PRESS	PRINTER LABEL	PRINTOUT	CALCULATOR PROMPTER
5a	Enter N_1	D	N	N_1	6.2
b	N_2	R/S	-	N_2	6.6
c	N_6	R/S	-	N_6	60
6	Enter ply data (see note 1)	3	-	-	3
7	Enter Θ_t	E	↑	Θ_t	
			R + Σ	R_t, R_t'	
				$\sigma_t^\circ, \sigma_t^{\circ\prime}$	$\sigma^{\circ\prime}$

OPTIONS

*	For sandwich construction (see note 2)			when prompter = c	
		A'	CR	c	
			SYM		
	Continue with step 4				

Notes:

1. Only one set of material properties, for either material 1 or material 2 may be kept in the storage registers at any one point in time. Therefore, to calculate the strength ratios and allowable stresses for a particular ply Θ_t, it is necessary to insure that the material properties correspond to the material that ply Θ_t is made from. Step 6 has the user enter these numbers using the pre-recorded ply data card described in program 1. This step can be emitted if a whole series of strength ratio calculations are to be performed for plies in one particular material. But the user is cautioned not to emit this step, if there is any doubt, to avoid large errors.
2. The number of equivalent plies of core material should be entered with material 2.

COMBO 4p HYBRID: IN—PLANE (PRT)

```
000  76   LBL         060  04    04         120  43   RCL         180  43   RCL
001  11     A         061  44   SUM         121  11    11         181  18    18
002  42   STO         062  36    36         122  44   SUM         182  42   STO
003  05    05 n(1)    063  36   PGM         123  17    17         183  12    12
004  57   ENG         064  12    12         124  43   RCL         184  99   PRT
005  58   FIX         065  71   SBR         125  12    12         185  43   RCL
006  03    03         066  71   SBR         126  44   SUM         186  19    19
007  00     0         067  97   DSZ         127  18    18         187  42   STO
008  49   PRD         068  05    05         128  43   RCL         188  13    13
009  09    09         069  00    00         129  13    13         189  99   PRT
010  49   PRD         070  51    51         130  44   SUM         190  43   RCL
011  16    16         071  71   SBR         131  19    19         191  20    20
012  49   PRD         072  53     (         132  43   RCL         192  42   STO
013  17    17         073  76   LBL         133  14    14         193  14    14
014  49   PRD         074  16    A'         134  44   SUM         194  99   PRT
015  18    18         075  01     1         135  20    20         195  43   RCL
016  49   PRD         076  05     5         136  43   RCL         196  21    21
017  19    19         077  03     3         137  15    15         197  42   STO
018  49   PRD         078  05     5         138  44   SUM         198  15    15
019  20    20         079  42   STO         139  21    21         199  99   PRT
020  49   PRD         080  02    02         140  91   R/S         200  98   ADV
021  21    21         081  36   PGM         141  76   LBL         201  36   PGM
022  03     3         082  11    11         142  12     B         202  11    11
023  01     1         083  71   SBR         143  42   STO n(2)    203  71   SBR
024  00     0         084  90   LST         144  05    05         204  35   1/X
025  02     2         085  43   RCL C       145  93     .         205  43   RCL
026  42   STO         086  05    05         146  01     1         206  16    16 Aij
027  02    02         087  99   PRT         147  00     0         207  99   PRT
028  36   PGM         088  76   LBL         148  03     3         208  43   RCL
029  11    11         089  53     (         149  42   STO         209  17    17
030  71   SBR         090  43   RCL         150  02    02         210  99   PRT
031  90   LST         091  59    59         151  36   PGM         211  43   RCL
032  00     0         092  65     ×         152  11    11         212  18    18
033  36   PGM         093  02     2         153  71   SBR         213  99   PRT
034  12    12         094  95     =         154  90   LST         214  43   RCL
035  71   SBR         095  36   PGM         155  61   GTO         215  19    19
036  61   GTO         096  12    12         156  00    00         216  99   PRT
037  43   RCL n(i)    097  71   SBR         157  32    32         217  43   RCL
038  05    05         098  61   GTO Via     158  76   LBL         218  20    20
039  99   PRT         099  03     3         159  13     C         219  99   PRT
040  98   ADV         100  06     6         160  01     1         220  43   RCL
041  65     ×         101  04     4         161  03     3         221  21    21
042  43   RCL         102  05     5         162  00     0         222  99   PRT
043  59    59         103  03     3         163  00     0         223  98   ADV
044  95     =         104  00     0         164  42   STO         224  01     1
045  44   SUM h       105  42   STO         165  02    02         225  07     7
046  09    09         106  02    02         166  36   PGM         226  05     5
047  93     .         107  36   PGM         167  11    11         227  01     1
048  05     5         108  11    11         168  71   SBR         228  42   STO
049  49   PRD n/2     109  71   SBR         169  90   LST         229  02    02
050  05    05 =t      110  90   LST         170  43   RCL         230  36   PGM
051  43   RCL         111  98   ADV         171  16    16         231  11    11
052  05    05         112  36   PGM         172  42   STO Aij     232  71   SBR
053  91   R/S         113  11    11         173  10    10         233  90   LST
054  99   PRT         114  71   SBR (i)     174  99   PRT         234  43   RCL
055  94   +/- Θt      115  23   LNX Aij     175  43   RCL         235  09    09
056  42   STO         116  43   RCL         176  17    17         236  35   1/X
057  35    35         117  10    10 (i)     177  42   STO         237  42   STO
058  01     1         118  44   SUM ΣAij    178  11    11         238  08    08
059  42   STO         119  16    16         179  99   PRT         239  55     ÷
```

COMBO 4p HYBRID: IN-PLANE (PRT)

```
240  43 RCL
241  16  16
242  95  =      Ei°
243  99 PRT
244  43 RCL
245  08  08
246  55  ÷
247  43 RCL
248  17  17
249  95  =
250  99 PRT
251  43 RCL
252  18  18
253  55  ÷
254  43 RCL
255  16  16
256  95  =
257  94 +/-
258  99 PRT
259  43 RCL
260  08  08
261  55  ÷
262  43 RCL
263  19  19
264  95  =
265  99 PRT
266  98 ADV
-------------
267  01  1
268  03  3
269  05  5
270  01  1
271  42 STO
272  02  02
273  36 PGM
274  11  11
275  71 SBR
276  90 LST
277  43 RCL
278  10  10   Aij
279  71 SBR
280  23 LNX
281  43 RCL
282  11  11
283  71 SBR
284  23 LNX
285  43 RCL
286  12  12
287  71 SBR
288  23 LNX
289  43 RCL
290  13  13
291  71 SBR
292  23 LNX
293  43 RCL
294  14  14
295  71 SBR
296  23 LNX
297  43 RCL
298  15  15
299  71 SBR

300  23 LNX
301  98 ADV
302  06  6
303  93  .
304  01  1
305  95  =
306  91 R/S
-------------   -
307  76 LBL
308  14  D
309  42 STO
310  26  26   N1
311  03  3
312  01  1
313  00  0
314  00  0
315  42 STO
316  02  02
317  36 PGM
318  11  11
319  71 SBR
320  90 LST
321  43 RCL
322  26  26
323  99 PRT
324  06  6
325  93  .
326  02  2
327  95  =
328  91 R/S
329  99 PRT
330  42 STO   N2
331  27  27
332  06  6
333  93  .
334  06  6
335  95  =
336  91 R/S
337  99 PRT
338  42 STO   N6
339  28  28
340  98 ADV
341  36 PGM
342  11  11
343  71 SBR
344  35 1/X   Aij
345  36 PGM
346  10  10
347  71 SBR   Ei°
348  89  π
349  36 PGM
350  10  10
351  71 SBR
352  34 √X    p,q,r,
353  43 RCL
354  53  53
355  42 STO
356  00  00
357  43 RCL
358  54  54
359  42 STO

360  01  01
361  43 RCL
362  55  55
363  42 STO
364  03  03
365  06  6    ↑Θ
366  00  0
367  95  =
368  91 R/S
-------------
369  76 LBL
370  15  E
371  42 STO
372  41  41   Θt
373  43 RCL
374  00  00
375  42 STO
376  53  53
377  43 RCL
378  01  01
379  42 STO
380  54  54
381  43 RCL
382  03  03
383  42 STO
384  55  55
385  43 RCL
386  44  44
387  42 STO
388  16  16
389  43 RCL
390  45  45
391  42 STO
392  17  17
393  43 RCL
394  46  46
395  42 STO
396  18  18
397  43 RCL
398  47  47
399  42 STO
400  19  19
401  43 RCL
402  48  48
403  42 STO
404  20  20
405  43 RCL
406  49  49
407  42 STO
408  21  21
409  06  6
410  00  0
411  00  0
412  42 STO
413  02  02
414  36 PGM
415  11  11
416  71 SBR
417  90 LST
418  43 RCL
419  41  41

420  99 PRT
421  98 ADV
422  36 PGM
423  10  10
424  71 SBR
425  54  )    Ei(Θt')
426  00  0
427  42 STO
428  26  26   Ei^n=σ
429  42 STO
430  27  27
431  42 STO
432  28  28
433  36 PGM
434  08  08
435  71 SBR   Gij
436  30 TAN
437  03  3
438  05  5
439  04  4
440  07  7
441  07  7
442  07  7
443  42 STO
444  02  02
445  36 PGM
446  11  11
447  71 SBR
448  90 LST
449  43 RCL   Rt
450  06  06
451  99 PRT
452  43 RCL   Rt'
453  07  07
454  99 PRT
455  98 ADV
456  43 RCL
457  06  06
458  55  ÷
459  43 RCL
460  09  09
461  95  =    σt°
462  99 PRT
463  43 RCL
464  07  07
465  55  ÷
466  43 RCL
467  09  09   σt°'
468  95  =
469  99 PRT
470  98 ADV
471  91 R/S
-------------   -
472  76 LBL
473  23 LNX
474  55  ÷    →Aij
475  43 RCL
476  [illegible]
477  95  =
478  99 PRT
479  92 RTN
```

4P SAMPLE PROBLEM HYBRID: IN-PLANE STIFFNESS AND STRENGTH

LAMINATE: $[0^{(1)}/90^{(2)}]_s$ **MATERIAL 1:** T300/5208 **MATERIAL 2:** Scotchply 1002

PROCEDURE	KEY	PRINT
Enter $n^{(1)}$	A	[illegible]
Enter θ_1	R/S	[illegible]
Enter $n^{(2)}$	B	[illegible]
Enter θ_1	R/S	[illegible]
PRINT A_{ij}	C	[illegible] [illegible] 06 [illegible] 06 [illegible] 06 [illegible] 06 0.[illegible] 00 [illegible] 00
PRINT a_{ij}		[illegible] [illegible]-09 [illegible] [illegible] [illegible] 00 0.[illegible] 00
PRINT E°_i		E= [illegible]4.541 09 24.689 09 102.[illegible]-03 5.[illegible]55 09
PRINT A^*_{ij}		A= 35.[illegible]01 09 14.[illegible]57 09 2.[illegible] 09 5.[illegible]55 09 0.[illegible]00 00 0.000 00

PROCEDURE	KEY	PRINT
ENTER N_1 N_2 N_6	D	N 1.[illegible] [illegible] [illegible]
ENTER θ_t[1]	E	[illegible]
PRINT R_t R'_t σ° $\sigma^{\circ\prime}$		[illegible]
ENTER θ_t[1]	E	[illegible]
PRINT R_t R'_t σ° $\sigma^{\circ\prime}$		R=1 [illegible]78.[illegible]57 0[illegible] 6[illegible]1.[illegible]09 0[illegible] 557.314 06 1.357 09

[1] Remember to use pre-recorded data card for each material to insure that the correct material properties are in storage.

4P SAMPLE PROBLEM HYBRID: IN-PLANE STIFFNESS AND STRENGTH

LAMINATE: $[0_2^{(1)}/90_1^{(2)}]_s$ **MATERIAL 1:** T300/5208 **MATERIAL 2:** Scotchply 1002

PROCEDURE	KEY	PRINT	PROCEDURE	KEY	PRINT
			ENTER N_1	D	[illegible]
			N_2		[illegible]
			N_6		[illegible]
Enter $n^{(1)}$	A	[illegible]	ENTER θ_t[1]	E	[illegible]
Enter θ_1	R/S	[illegible]	PRINT R_t		[illegible]
θ_2	R/S	[illegible]	R_t'		[illegible]
Enter $n^{(2)}$	B	[illegible]	σ°		[illegible]
			$\sigma^{\circ\prime}$		[illegible]
Enter θ_1	R/S	[illegible]	ENTER θ_t[1]	E	[illegible]
PRINT A_{ij}	C	[illegible]	PRINT R_t		[illegible]
			R_t'		[illegible]
			σ°		[illegible]
			$\sigma^{\circ\prime}$		1.772 09
PRINT a_{ij}		[illegible]			
PRINT E_i°		[illegible]			
PRINT A_{ij}^*		[illegible]			

[1] Remember to use pre-recorded data card for each material to insure that the correct material properties are in storage.

4P SAMPLE PROBLEM HYBRID: IN-PLANE STIFFNESS AND STRENGTH

LAMINATE: $[90^{(1)}/0^{(2)}]_s$ **MATERIAL 1:** T300/5208 **MATERIAL 2:** Scotchply 1002

PROCEDURE	KEY	PRINT	PROCEDURE	KEY	PRINT
			ENTER N_1 N_2 N_6	D	N 1.000 00 0.000 00 0.000 00
			ENTER Θ_t[1]	E	t 90.000 00
Enter $n^{(1)}$ Enter Θ_1 Enter $n^{(2)}$ Enter Θ_1	A R/S B R/S	n1 1.000 00 90.000 00 [illegible] n2 1.000 00 0.000 00 [illegible]	PRINT R_t R'_t σ° $\sigma^{\circ\prime}$		R+I 48.000 03 242.517 03 95.599 06 585.034 06
			ENTER Θ_t[1]	E	t 0.000 00
PRINT A_{ij}	C	A 12.378 06 47.551 06 1.270 06 1.327 06 0.000 00 0.000 00	PRINT R_t R'_t σ° $\sigma^{\circ\prime}$		R+I 230.498 03 360.794 03 460.996 06 720.187 06
PRINT a_{ij}		51.708-09 21.368-09 -1.381-09 351.669-09 0.000 00 0.000 00			
PRINT E_i°		E- 1[illegible].[illegible]69 09 46.641 09 26.702-03 5.655 09			
PRINT A_{ij}^*		A* 24.757 09 45.101 09 1.539 09 5.655 09 0.000 00 0.000 00			

[1] Remember to use pre-recorded data card for each material to insure that the correct material properties are in storage.

4P SAMPLE PROBLEM HYBRID: IN-PLANE STIFFNESS AND STRENGTH

LAMINATE: $[0_4^{(1)}/90_4^{(2)}]_s$ **MATERIAL I:** T300/5208 **MATERIAL 2:** Scotchply 1002

PROCEDURE	KEY	PRINT
Enter $n^{(1)}$	A	N1 8.000 00
Enter Θ_1 Θ_2 Θ_3 Θ_4	R/S R/S R/S R/S	0.000 00 0.000 00 0.000 00 0.000 00 END
Enter $n^{(2)}$	B	N2 8.000 00
Enter Θ_1 Θ_2 Θ_3 Θ_4	R/S R/S R/S R/S	90.000 00 90.000 00 90.000 00 90.000 00 END
PRINT A_{ij}	C	A 190.203 06 49.513 06 5.079 06 11.310 06 0.000 00 0.000 00
PRINT a_{ij}		5.272-09 20.152-09 -540.742-12 18.417-09 0.000 00 0.000 00
PRINT E_i^o		E* 54.741 09 24.419 09 102.573-03 5.155 09
PRINT A_{ij}^*		A* 95.101 09 24.757 09 2.579 09 5.655 09 0.000 00 0.000 00

PROCEDURE	KEY	PRINT
ENTER N_1 N_2 N_6	D	N 1.000 00 0.000 00 0.000 00
ENTER Θ_t[1]	E	T 0.000 00
PRINT R_t R_t' $\sigma°$ $\sigma°'$		R-I 1.418 06 1.890 06 719.152 06 995.196 06
ENTER Θ_t[1]	E	T 90.000 00
PRINT R_t R_t' $\sigma°$ $\sigma°'$		R-I 714.408 03 2.714 06 257.714 06 [illegible]

[1] Remember to use pre-recorded data card for each material to insure that the correct material properties are in storage.

4P SAMPLE PROBLEM HYBRID: IN-PLANE STIFFNESS AND STRENGTH

LAMINATE: $[0_2^{(1)}/90_2^{(2)}/c_2]_s$ MATERIAL 1: T300/5208 MATERIAL 2: Scotchply 1002

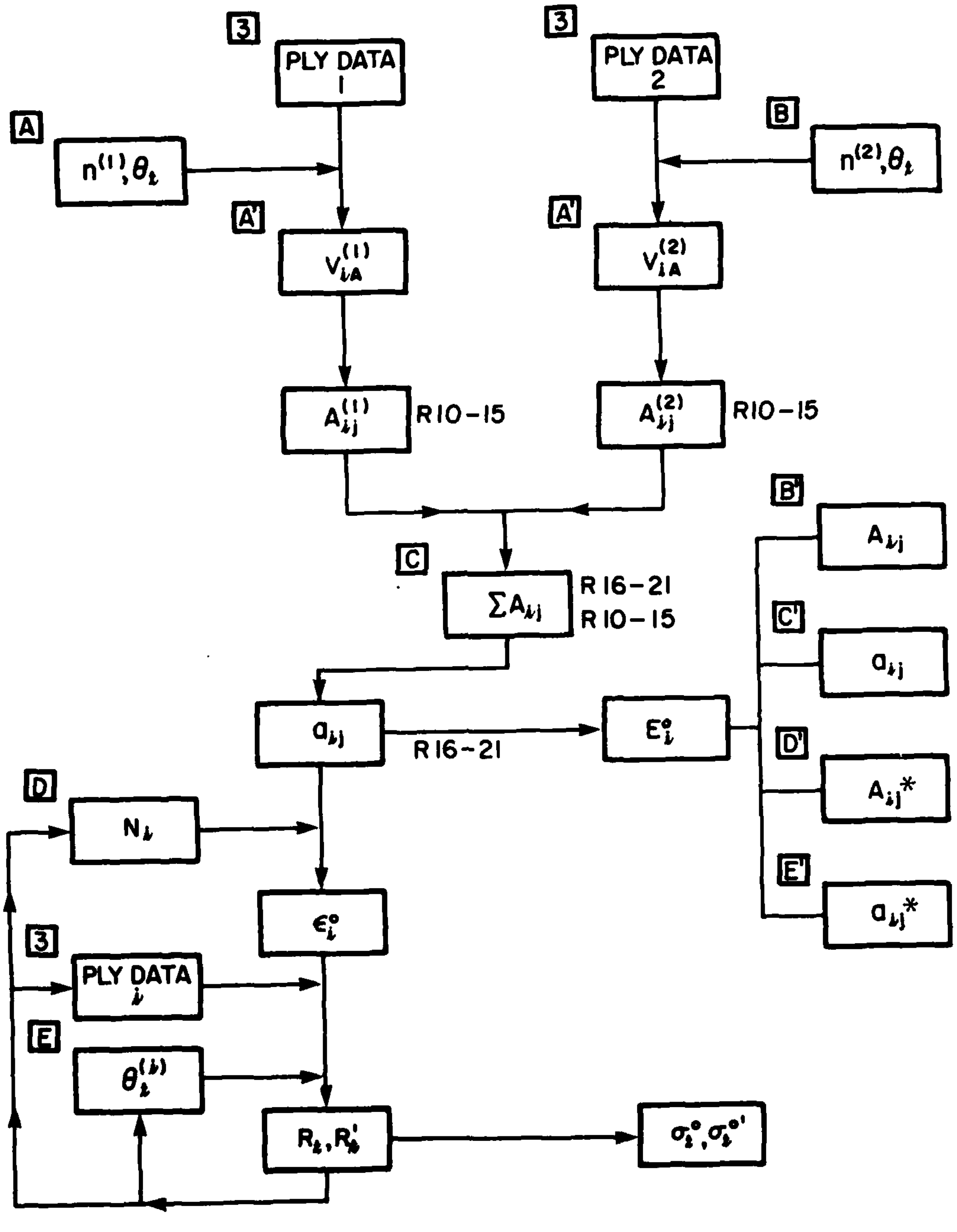
PROCEDURE	KEY	PRINT
Enter $n^{(1)}$	A	[illegible]
Enter θ_1	R/S	[illegible]
Enter θ_2	R/S	[illegible]
Enter $n^{(2)}$	B	[illegible]
Enter θ_1	R/S	[illegible]
θ_2	R/S	[illegible]
	A'	[illegible]
PRINT A_{ij}	C	[illegible] [illegible] [illegible] [illegible] [illegible] 0.000 00
PRINT a_{ij}		10.544-09 40.504-09 -1.082-09 176.835-09 0.000 00 0.000 00
PRINT E_i°		E* 53.227 09 16.459 09 [illegible] 3.770 09
PRINT A^*_{ij}		A* [illegible] 16.504 09 1.693 09 3.770 09 0.000 00 0.000 00

PROCEDURE	KEY	PRINT
ENTER N_1	D	[illegible]
N_2		[illegible]
N_6		[illegible]
ENTER Θ_t[1]	E	[illegible]
PRINT R_t		[illegible]
R'_t		[illegible]
σ°		[illegible]
$\sigma^{\circ\prime}$		[illegible]
ENTER Θ_t[1]	E	[illegible]
PRINT R_t		[illegible]
R'_t		[illegible]
σ°		330.309 06
$\sigma^{\circ\prime}$		904.679 06

[1] Remember to use pre-recorded data card for each material to insure that the correct material properties are in storage.

NOTES

COMBO #4
HYBRID: IN-PLANE STIFFNESS AND STRENGTH



COMBO #4 HYBRID: IN-PLANE STIFFNESS AND STRENGTH

A' core	B' A_{ij}	C' a_{ij}	D' A^*_{ij}	E' a^*_{ij}
A material 1 $n^{(1)}, \Theta_t^{(1)}$	B material i $n^{(i)}, \Theta_t^{(i)}$	C E_i°	D $N_i \rightarrow \varepsilon_i^\circ$	E $\Theta_t \rightarrow R_t, \sigma^\circ$

00 USED	15 $A_{26}^{(i)}$	30 $U_1^{(i)}$	45 $G_{yy}^{(i)}$
01 USED	16 $\Sigma A_{11}^{(i)}, a_{11}, G_{xx}^{(i)}$	31 $U_2^{(i)}$	46 $G_{xy}^{(i)}$
02 USED	17 $\Sigma A_{22}^{(i)}, a_{22}, G_{yy}^{(i)}$	32 $U_3^{(i)}$	47 $G_{ss}^{(i)}$
03 USED	18 $\Sigma A_{12}^{(i)}, a_{12}, G_{xy}^{(i)}$	33 $U_4^{(i)}$	48 $G_x^{(i)}$
04 USED	19 $\Sigma A_{66}^{(i)}, a_{66}, G_{ss}^{(i)}$	34 $U_5^{(i)}$	49 $G_y^{(i)}$
05 $n^{(i)}$, c	20 $\Sigma A_{16}^{(i)}, a_{16}, G_x^{(i)}$	35 Θ	50
06 R_t	21 $\Sigma A_{26}^{(i)}, a_{26}, G_y^{(i)}$	36 $V_o^{(i)}$	51
07 R_t'	22 $\|A\|$	37 $V_1^{(i)}$	52
08 1/h	23 ε_1°	38 $V_3^{(i)}$	53 p
09 h	24 ε_2°	39 $V_2^{(i)}$, USED	54 q
10 $A_{11}^{(i)}$	25 ε_6°	40 $V_4^{(i)}$	55 r
11 $A_{22}^{(i)}$	26 N_1, 0	41 Θ	56 USED
12 $A_{12}^{(i)}$	27 N_2, 0	42 USED	57 USED
13 $A_{66}^{(i)}$	28 N_6, 0	43 USED	58 USED
14 $A_{16}^{(i)}$	29 USED	44 $G_{xx}^{(i)}$	59 h_o

COMBO #4 HYBRID: IN-PLANE STIFFNESS AND STRENGTH

STEP	PROCEDURE	PRESS	DISPLAY/PROMPTER
0	Enter ply data #1	3	3
1a	Enter $n^{(1)}$	A	n/2
b	Θ_1	R/S	n/2 - 1
c	Θ_2	R/S	n/2 - 2
.	.	.	.
.	.	.	.
.	.	.	.
	$\Theta_{n/2-1}$	R/S	1
	$\Theta_{n/2}$	R/S	0
2	Enter ply data #2	3	3
3a	Enter $n^{(2)}$	B	n/2
b	Θ_1	R/S	n/2 - 1
c	Θ_2	R/S	n/2 - 2
.	.	.	.
.	.	.	.
.	.	.	.
	$\Theta_{n/2-1}$	R/S	1
*	$\Theta_{n/2}$	R/S	0
4 **	Compute E_i°	C,R/S...	$E_1^\circ, E_2^\circ, \nu_{21}^\circ, E_6^\circ$, 6.1
5	Enter N_1	D	6.2
	N_2	R/S	6.6
	N_6	R/S	60

COMBO #4 CONTINUED

STEP	PROCEDURE	PRESS	DISPLAY/PROMPTER
6	Enter ply data (see note 1)	3	3
7	Enter Θ_t	E	R_t
		R/S	R_t'
		R/S	σ_t^o
		R/S	$\sigma_t^{o\prime}$
		R/S	60

OPTIONS

*	For sandwich construction (see note 2)	-	when prompter = c
		A'	0
	continue with step 4		
**	Calculate A_{ij}	B'	A_{11}, A_{22}, A_{12}, A_{66}, A_{16}, A_{26}, 6.1
	a_{ij}	C'	a_{11}, a_{22}, a_{12}, a_{66}, a_{16}, a_{26}, 6.1
	A^*_{ij}	D'	A^*_{11}, A^*_{22}, A^*_{12}, A^*_{66}, A^*_{16}, A^*_{26}, 6.1
	a^*_{ij}	E'	a^*_{11}, a^*_{22}, a^*_{12}, a^*_{66}, a^*_{16}, a^*_{26}, 6.1

Notes:

1. Only one set of material properties, for either material 1 or material 2 may be kept in the storage registers at any one point in time. Therefore, to calculate the strength ratios and allowable stresses for a particular ply Θ_t, it is necessary to insure that the material properties correspond to the material that ply Θ_t is made from. Step 6 has the user enter these numbers using the pre-recorded ply data card described in program 1. This step can be emitted if a whole series of strength ratio calculations are to be performed for plies in one particular material. But the user is cautioned not to emit this step, if there is any doubt, to avoid large errors.

2. The number of equivalent plies of core material should be entered with material 2.

COMBO 4 HYBRID: IN-PLANE

```
[illegible]                 n(1)
[illegible]
026  76  LBL                n(i)
[illegible]
028  43  RCL
029  05   05
030  42  STO
[illegible]
033  43  RCL
[illegible]
035  95   =
036  44  SUM                h
[illegible]
040  49  PRD                n/2=
041  05   05
042  43  RCL                t
043  05   05
044  91  R/S
045  94  +/-
046  42  STO                θt
047  35   35
048  01   1
049  42  STO
050  04   04
051  44  SUM
052  36   36
053  36  PGM
054  12   12
055  71  SBR
056  71  SBR
057  97  DSZ
058  05   05
059  00   00
```

```
[illegible]                 C
                            Via
                            Aij(i)
                            ΣAij(i)
[illegible]
101  76  LBL                n(2)
102  12   B
103  42  STO
104  05   05
105  00   0
106  36  PGM
107  12   12
108  71  SBR
109  61  GTO
110  71  SBR
111  35  1/X
112  76  LBL
113  13   C
114  43  RCL                Aij
115  16   16
116  42  STO
117  10   10
118  43  RCL
119  17   17
```

```
[illegible]                 Aij
                            E_i^0
[illegible]
162  43  RCL
163  16   16
164  95   =
165  94  +/-
166  91  R/S
167  43  RCL
168  08   08
169  55   ÷
170  43  RCL
171  19   19
172  95   =
173  91  R/S
174  06   6
175  93   .                 N1
176  01   1
177  95   =
178  91  R/S
179  76  LBL
```

```
[illegible]                 N2
                            N6
                            Aij
                            E_i^0
                            p,q,r,
[illegible]
214  43  RCL
215  54   54
216  42  STO
217  01   01
218  43  RCL
219  55   55
220  42  STO
[illegible]                 ↑θ
223  95   =
224  91  R/S
225  76  LBL
226  15   E
227  42  STO                θt
228  41   41
229  43  RCL
230  00   00
231  42  STO
232  53   53
233  43  RCL
234  01   01
235  42  STO
236  54   54
237  43  RCL
238  03   03
239  42  STO
```

COMBO 4 HYBRID: IN-PLANE

```
[illegible] [illegible] [illegible]
[illegible] [illegible] RCL
[illegible] [illegible] 44
[illegible] [illegible] STO
[illegible] [illegible] 16
[illegible] [illegible] RCL
[illegible] [illegible] 45
[illegible] [illegible] STO
[illegible] [illegible] 17
[illegible] 43 RCL
[illegible] [illegible] 46
[illegible] [illegible] STO
[illegible] [illegible] 18
[illegible] [illegible] RCL
[illegible] [illegible] 47
[illegible] [illegible] STO
[illegible] [illegible] 19
[illegible] [illegible] RCL
[illegible] [illegible] 48
[illegible] [illegible] STO
[illegible] [illegible] 20
[illegible] [illegible] RCL
[illegible] [illegible] 49
[illegible] [illegible] STO
[illegible] [illegible] [illegible]
[illegible] [illegible] PGM
[illegible] [illegible] 16
[illegible] [illegible] SBR
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] RCL
[illegible] [illegible] 08
[illegible] 55 -
[illegible] 43 RCL
[illegible] 09 09
[illegible] 95 =
[illegible] 91 R/S
[illegible] 43 RCL
[illegible] 07 07
295 55 -
296 43 RCL
297 09 09
298 95 =
299 91 R/S
```

```
300 06 6
301 00 0
302 95 =
303 91 R/S
304 71 SBR
305 15 E
306 91 R/S
307 76 LBL
308 17 B'      Aij
309 43 RCL
310 10 10
311 91 R/S
312 43 RCL
313 11 11
314 91 R/S
315 43 RCL
316 12 12
317 91 R/S
318 43 RCL
319 13 13
320 91 R/S
321 43 RCL
322 14 14
323 91 R/S
324 43 RCL
325 15 15
326 91 R/S
327 06 6
328 93 .       Ei'(θt)
329 01 1
330 95 =
331 91 R/S     Ei^n-0
332 76 LBL
333 16 C'      Aij
334 43 RCL
335 16 16
336 91 R/S
337 43 RCL
338 17 17
339 91 R/S     Gij
340 43 RCL
341 18 18      Rt
342 91 R/S
343 43 RCL
344 19 19      R't
345 91 R/S
346 43 RCL
347 20 20
348 91 R/S
349 43 RCL
350 21 21
351 91 R/S     σt°
352 05 5
353 93 .
354 01 1
355 95 =
356 91 R/S     σt°'
357 76 LBL
358 19 D'      Aij•
359 43 RCL
```

```
360 10 10
361 55 -
362 43 RCL
363 09 09
364 95 =
365 91 R/S
366 43 RCL
367 11 11
368 55 -
369 43 RCL
370 09 09
371 95 =
372 91 R/S
373 43 RCL
374 12 12
375 55 -
376 43 RCL
377 09 09
378 95 =
379 91 R/S
380 43 RCL
381 13 13
382 55 -
383 43 RCL
384 09 09
385 95 =
386 91 R/S
387 43 RCL
388 14 14
389 55 -
390 43 RCL
391 09 09
392 95 =
393 91 R/S
394 43 RCL
395 15 15
396 55 -
397 43 RCL
398 09 09
399 95 =
400 91 R/S
401 06 6
402 93 .
403 01 1
404 95 =
405 91 R/S
406 76 LBL
407 10 E'      Aij+
408 43 RCL
409 16 16
410 65 ×
411 43 RCL
412 09 09
413 95 =
414 91 R/S
415 43 RCL
416 17 17
417 65 ×
418 43 RCL
419 09 09
```

```
420 95 =
421 91 R/S
422 43 RCL
423 18 18
424 65 ×
425 43 RCL
426 09 09
427 95 =
428 91 R/S
429 43 RCL
430 19 19
431 65 ×
432 43 RCL
433 09 09
434 95 =
435 91 R/S
436 43 RCL
437 20 20
438 65 ×
439 43 RCL
440 09 09
441 95 =
442 91 R/S
443 43 RCL
444 21 21
445 65 ×
446 43 RCL
447 09 09
448 95 =
449 91 R/S
450 06 6
451 93 .
452 01 1
453 95 =
454 91 R/S
455 00 0
456 00 0
457 00 0
458 00 0
459 00 0
460 00 0
461 00 0
462 00 0
463 00 0
464 00 0
465 00 0
466 00 0
467 00 0
468 00 0
469 00 0
470 00 0
471 00 0
472 00 0
473 00 0
474 00 0
475 00 0
476 00 0
477 00 0
478 00 0
479 00 0
```

*U.S.Government Printing Office: 1982 — 559-006/5089

FILMED

8-8